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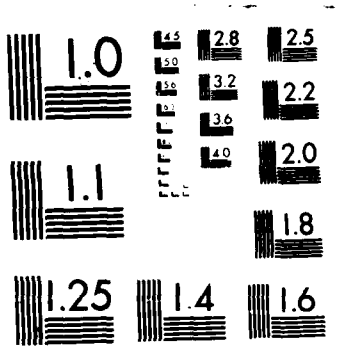

PREPARATION AND PROPERTIES OF ARRAYS OF VERY SMALL MAGNETIC PARTICLES

FINAL REPORT

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U.S. ARMY RESEARCH OFFICE

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DEPARTMENT OF MATERIALS SCIENCE AND ENGINEERING
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Final Report

PREPARATION AND PROPERTIES OF ARRAYS OF VERY SMALL MAGNETIC PARTICLES

The aim of this project was to learn to make two-dimensional arrays of small magnetic particles by electron beam lithography and etching of thin films, and to learn to make magnetic measurements on the arrays. The purpose was to investigate experimentally the behavior of magnetic particles in the size range down to and including single-domain behavior, and also to study experimentally the problem of particle-particle interactions on the magnetic properties of arrays of small particles.

Sputtered amorphous films of $Fe_{80}B_{20}$ on glass or silicon substrates were used as starting samples, to eliminate non-uniform etching at grain boundaries. Electron-beam lithography and etching were done at the National Sub-Micron Research Resource Facility at Cornell. Etching was done by ion milling, with generally satisfactory results. We were able to reach the current size limit of the equipment at Cornell, with etched particles approximately 2500 x 1200 A in cross-section by 25 um long, spaced about 3000 A apart. The particle array was of the order of 1 mm by 1mm square. A limitation of this preparation method is that the particle arrays are two-dimensional rather than three-dimensional.

A magnetic measurement technique with sufficient sensitivity to measure the small magnetic moment of these two-dimensional arrays was developed, using a Hall-effect element as the sensor in a vibrating-sample magnetometer. The magnetometer was connected to a computer data-collection system, using a DEC 11-23 machine.

At the smallest particle size we reached, the particles are not single-domain, and the coercive field of the array is about 100 Oe. With newer equipment now installed at Cornell, or by carrying out the electron-beam lithography in a modified scanning electron microscope, it should be possible to produce samples with dimensions less than 1000 A; such samples should show single-domain behavior.

In summary, techniques for preparing highly uniform two-dimensional arrays of small magnetic particles (approaching the single-domain size range) have been developed, and appropriate measuring equipment has been built and tested. The student recruited for the project has completed the work for his Master's degree in Materials Science and Engineering, and the degree will be awarded in May 1987.

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Techniques were developed to produce two-dimensional arrays of magnetic particles with minimum dimensions of about 2500 A, and to measure their magnetic properties. The purpose of the work was to provide a clean experimental test of the behavior of magnetic particles in the single-domain size range, especially of the effects of particle interactions in this size range. The particles produced were too large to show single-domain behavior, but with improved electron-beam lithography equipment it should be possible to produce arrays of smaller particles. An improved vibrating-sample magnetometer was developed to permit measurement of the magnetic properties of these very small samples.

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